Nanofabricated Optomechanical Whispering Gallery Mode Resonators

Completed Technology Project (2011 - 2013)

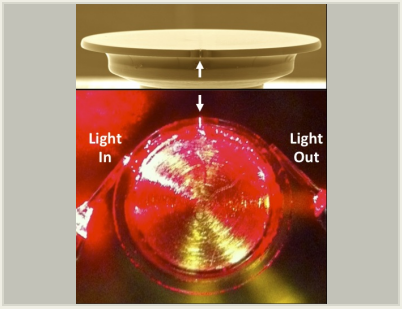
Project Introduction

The objective of this task are to: develop nanofabrication processes compatible with high-Q optical resonators; improve optical quality factor; implement FIB engraved discs; demonstrate optomechanical measurements; publish results and write proposals.

Strong interest in whispering gallery mode resonators (WGMR) for use in chip-scale photonic devices is motivated by their high optical quality, mechanical simplicity and extremely compact form. In these circular resonators, the light propagates around the circumference, localized by total internal reflection at the dielectric boundary. The typical WGMR geometry is constrained because the full mode intensity is not accessible. Only a small portion of the mode volume, the evanescent field that exists just outside the disc perimeter, is exposed for external optomechanical coupling or molecular sensing applications. In this research, we make use of focused ion beam (FIB) microfabrication to mill features into the WGMR. FIB engineered disc (FIBED) resonators can be formed with open structure, i.e. a milled notch creates a free space gap within the mode volume. The gap provides access to the internal fields of the resonator, and therefore the full mode intensity. This novel approach allows direct interaction of external mechanisms, atoms, or molecules with the resonant light field. We have demonstrated a calcium fluoride FIBED resonator with optical quality factor (Q) exceeding a million. With our developed FIB process, charge collection and material re-deposition issues have been mitigated, and we observe no effects of gallium ion contamination. In our initial demonstrations, the optical Q appears to be limited by Rayleigh scattering losses from the notch surface roughness. The FIB milling can ultimately achieve 20 times better surface finish, which will greatly enhance the optical Q. This novel open cavity WGMR allows interaction of external mechanisms with the full intensity of the resonant light field. In particular, a mechanical resonator can be engineered within the high-Q cavity to realize a monolithic optomechanical device. Optomechanical coupling to the WGMR field yields extremely high sensitivity to the displacement and motion of the mechanical resonator.

Anticipated Benefits

N/A



Project Image Nanofabricated Optomechanical Whispering Gallery Mode Resonators

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

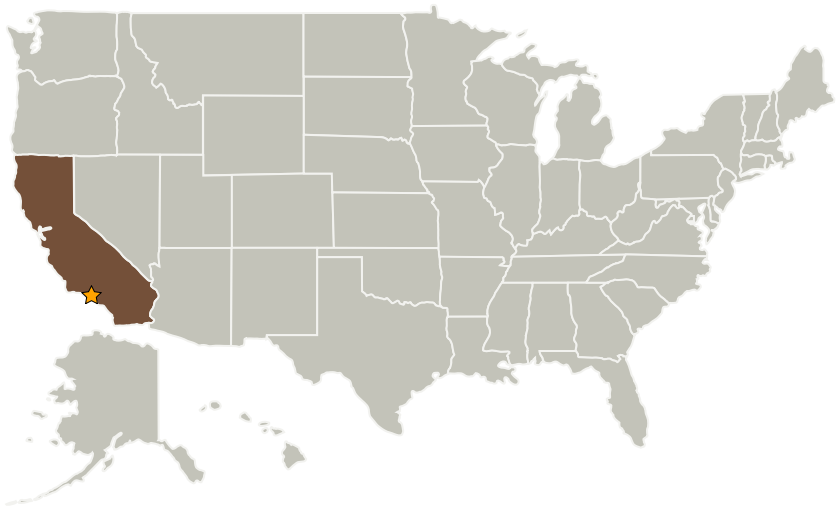
Center Innovation Fund: JPL CIF

Center Innovation Fund: JPL CIF

Nanofabricated Optomechanical Whispering Gallery Mode Resonators

Completed Technology Project (2011 - 2013)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:
Michael R Lapointe

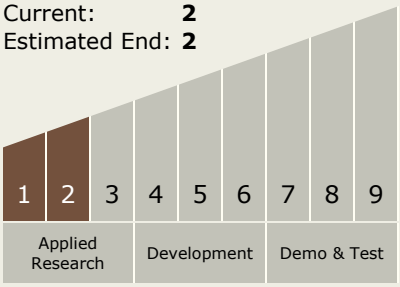
Program Manager:
Fred Y Hadaegh

Project Manager:
Jonas Zmuidzinas

Principal Investigator:
David C Aveline

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



Technology Areas

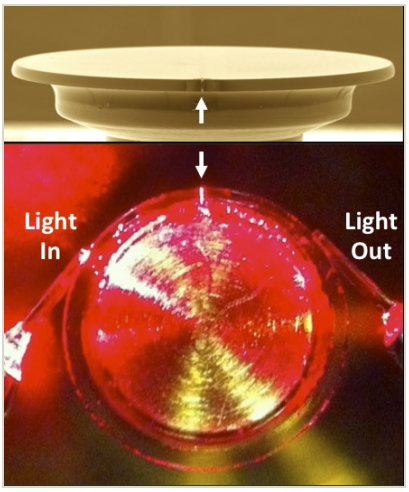
Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.4 Manufacturing
    - TX12.4.3 Electronics and Optics Manufacturing Process

Nanofabricated Optomechanical Whispering Gallery Mode Resonators

Completed Technology Project (2011 - 2013)

Images



142.png
Project Image Nanofabricated Optomechanical Whispering Gallery Mode Resonators
(https://techport.nasa.gov/image/1193)